SPACED LOAD PATTERNS FOR IMPROVED TEMPERATURE CONTROL IN EXPORT SHIPMENTS OF LETTUCE

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SPACED LOAD PATTERNS FOR IMPROVED TEMPERATURE CONTROL IN EXPORT SHIPMENTS OF LETTUCE

By JOSEPH K. STEWART,[1] *horticulturist;* ANTON BONGERS,[2] *agricultural assistant;* and RUSSEL H. HINDS, JR.,[1] *industry economist, Market Quality and Transportation Research Laboratory, Western Region, Agricultural Research Service*

SUMMARY AND RECOMMENDATIONS

Test shipments of lettuce to overseas markets were made to compare the modified bonded block (MBB) and the pigeonhole (PH) load patterns. Solid loads were not tested in the overseas shipments because they proved unsatisfactory for even the short transit period from harvest area to the port, as indicated by excessive temperatures within parts of the loads. Both spaced load patterns provided equally good air circulation in refrigerated van containers as indicated by uniform temperatures throughout the loads. Load shifting or crushing of the bottom layer cartons did not differ in the two types of load. Quality of the lettuce at destination also was the same from both load patterns. Thus, the choice of which loading pattern to use can be based on the dimensions of the van and the package, because one of the loading patterns might fit into a specific van better than the other. Further, some loading crews object to the MBB pattern, and, in some instances, charge a premium for using it. Thus, labor or economics, or both, may be an important consideration in the choice of load pattern.

A spaced load pattern, rather than a solid load pattern, should be used in truck trailer loads of lettuce during the inland trip to the port because high temperatures often develop in the solid loads. A solid load pattern for the inland trip may be acceptable if it is only for about 1 day, but additional research is needed in this area.

INTRODUCTION

Exports of Western lettuce have increased during the past several years, but have been limited because of relatively high risks. There is still much to learn before iceberg lettuce can be consistently delivered to overseas markets in good condition. Proper temperature control throughout the load is the most important factor in maintaining the quality of lettuce during transport. In past years, researchers at the U.S. Department of Agriculture laboratory in Rotterdam have observed many loads of lettuce on arrival from the United States in which temperatures were excessively high and decay losses were severe because of tight or improper load patterns. To improve temperature control, we compared two spaced loading patterns and evaluated market quality of lettuce shipped in refrigerated van containers from the Western United States to Europe and the Far East.

[1] Fresno, Calif.

[2] European Marketing Research Center, Rotterdam, the Netherlands.

METHODS

Test Procedures

Four export shipping tests were conducted in 1974 to compare two different spaced loading patterns. Each test was a paired shipment of lettuce in two identical refrigerated van containers, hereafter referred to as vans. One van in each pair was loaded with one of the spaced loading patterns, and the other van was loaded with the other pattern. Both patterns provide channels throughout the loads to facilitate air circulation. Solid load patterns were not included in the export tests because of the danger of reduced lettuce quality from inadequate air circulation and warm temperatures in the load. On all test vans, thermostats were set at 34° F and fans operated continuously.

The lettuce for the first two tests was trucked from California to the port, where it was transferred into the test vans (table 1). The solid load pattern normally used by the industry was used in the over-the-road trailers. The spaced test patterns were used when the lettuce was transferred to the vans at the port. These vans were shipped to Rotterdam, the Netherlands, and then trucked about 10 miles to the receiver's warehouse. No stops en route were made during the ocean trip.

The lettuce for the last two tests was loaded directly into the test vans at the harvest area in California, using the two test load patterns. These vans were then trucked over-the-road to the port in California. These vans were shipped to Hong Kong. The ship made stops en route at Yokohama and Kobe, Japan. All test vans were on the deck of a container ship during the ocean trip.

At shipping point, test packages were selected at random from the commercially harvested and packed lettuce by USDA personnel making certain that all test lettuce for a given pair of vans was from the same field and that the test lettuce for the four paired shipments was from four different fields. In tests 1 and 2, each test package contained 2½ dozen heads and in tests 3 and 4, 2 dozen heads. In all tests, the heads were film wrapped in the field and packed into nonwaxed cartons.

The vans shipped to Rotterdam (tests 1 and 2) each had six test packages of lettuce. These were placed in the load in the same positions as the recording thermometers used in test 2 (fig. 1). The vans shipped to Hong Kong (tests 3 and 4) each had three test packages, all of which were placed in the middle layer of the third from the last stack to facilitate recovery at destination.

Ryan recording thermometers, placed in the centers of the test packages of lettuce, were used to monitor temperatures in the four van loads shipped to Rotterdam. In each of the vans shipped to Hong Kong, commodity temperatures were measured in transit with thermocouples and a potentiometer (fig. 1). Air temperatures were measured above each load at the air duct discharge opening (centerline at about the three-quarter length). Ryan thermometers were used in the shipments to Europe, and thermocouples were used in the shipments to Hong Kong.

TABLE 1.—*Log of test shipments, 1974*

Test No.	Harvest [1]		Transfer [2]		Ship				Date test packages were recovered from vans
					Sailed		Arrived		
	Area	Date	Area	Date	Port	Date	Port	Date	
1	Blythe	3/12	New Orleans	3/15	New Orleans	3/18	Rotterdam	3/29	3/29
2	Salinas	5/ 6	Jersey City	5/10	Elizabeth	5/13	----- do -----	5/18	5/20
3	----- do -----	8/ 1	----------	-------	Oakland	8/ 3	Hong Kong	8/17	8/17
4	----- do -----	8/ 1	----------	-------	----- do -----	8/ 3	----- do -----	8/17	8/17

[1] The lettuce was trucked from the harvest area in California on the day of harvest.

[2] In tests 1 and 2, the lettuce was transferred from the over-the-road trailer to the test vans in the port area. In tests 3 and 4, the lettuce was loaded directly into the test vans at shipping point.

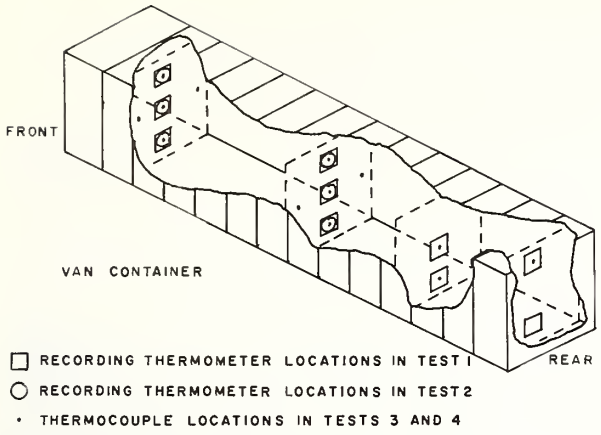

FIGURE 1.—Diagram of thermocouple and recording thermometer locations in cartons of lettuce shipped in refrigerated van containers to Europe or the Far East.

At destination, half the lettuce from each test package was evaluated by USDA personnel for quality on arrival. The remaining half was examined after a 3- to 5-day holding period at 50° F. Load shifting and carton crushing were also observed.

During the quality evaluations, heads considered unsalable were trimmed of outer leaves (retail trimming) to try to make them salable. All heads in test packages were subsequently torn apart so that all defective tissue could be trimmed (consumer trimming). The percentage of trim losses were determined by weight. Defects found in the consumer trimming included the following: Decay, tipburn, wilted leaves, russet spotting, rib discoloration, pink rib, brown stain, and tissue discolored for any other reason, such as the pink or dark discoloration of crushed and bruised areas.

The rating scale used to evaluate the overall general appearance of the lettuce was: 1, inedible; 2, poor; 3, fair; 4, good; 5, excellent. Heads that were rated 2 or lower were considered to be unsalable, and then were trimmed, as by the retailer, in an effort to make them salable. All defects were rated on the following scale: 1, none; 2, trace; 3, slight; 4, moderate; and 5, severe. Intermediate ratings of 0.5 were used in both rating scales.

The two spaced load patterns tested were the modified bonded block (MBB) and the pigeonhole (PH). The description of the two load patterns follows.

Modified Bonded Block Load

The MBB pattern consists of cartons placed both lengthwise and crosswise in two interlocking stacks to form one complete single block (figs. 2 and 3). Ten such blocks were placed in the 35-foot refrigerated vans used in these tests. This pattern provided both vertical and horizontal channels for air movement.

Continuity of the channels between cartons placed lengthwise in the MBB load is essential to provide

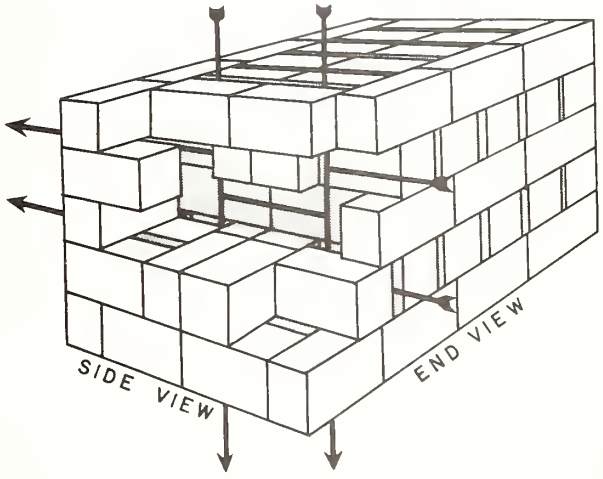

FIGURE 2.—Diagram of the modified bonded block (MBB) load pattern. Air circulates horizontally and vertically throughout the load.

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FIGURE 3.—Cross section of one of the modified bonded block (MBB) loads used in test shipments to Europe.

uniform air circulation throughout the load. Crosswise cartons in this pattern should be tightly stacked to provide load stability.

The MBB load shown in figure 3 is well suited to the dimensions of the carton and van shown. Four cartons fit snugly crosswise in the van. The outside dimensions of this carton are 21.6 inches long by 10.4 inches wide by 14.6 inches high. Some cartons with larger dimensions will fit with only three crosswise, thus wasting space. In such cases, it may be desirable to use one continuous row along one wall. This row, termed "fill-in row," is not part of the spaced pattern (see "Discussion").

To assure that the cold discharge air reaches the rear of the load, the top layer of the front half of the MBB load should be stacked solid, that is, the vertical air channels should be blocked. This is accomplished by placing one additional carton in the lengthwise stack of the top layer of each block of cartons.

A header stack, as described in the discussion of the PH load, can be used with the MBB load pattern to assure adequate space for air return at the front of the vehicle. However, because of the numerous vertical air spaces throughout the load that lead to the floor racks under the load, a header stack is not essential in the MBB load. If a header stack is used, these cartons must be alined with the lengthwise cartons in the MBB pattern.

The pattern of the MBB load should be laid out along one side wall for the entire length of the van or trailer before loading (fig. 4). If excessive space exists at the rear after the last block is laid out, a fill-in stack can be added between any two complete blocks in the vehicle. This fill-in stack is the same as the header stack at the front of the vehicle and is placed between any two blocks to facilitate load length (fig. 5). This fill-in stack should not be used at the very rear of the van as it would not be stable.

Pigeonhole Load

The PH load pattern provides lengthwise channels in alternate layers of the load for longitudinal air circulation from the rear to the front of the vehicle. Usually, all cartons are loaded lengthwise in a PH load (figs. 6 and 7). However, when the carton width is one-half of its length, the cartons in the spaced layers can be placed crosswise, while those in the solid layers remain lengthwise. In the spaced layers, three cartons are placed crosswise, and the spaces between cartons and walls and between cartons are equal. This pattern, which was used in tests 3 and 4, is believed, by some people in the industry, to in-

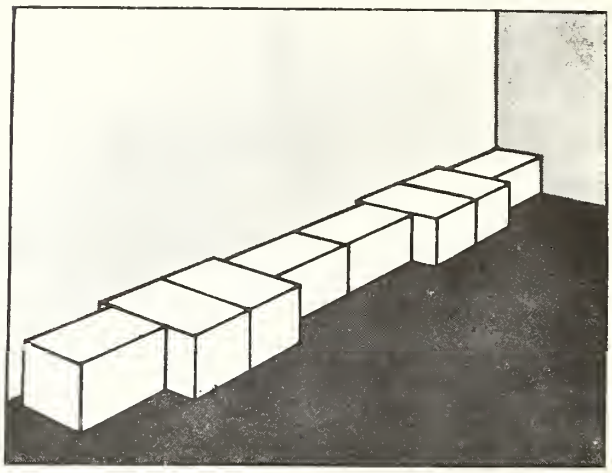

FIGURE 4.—Diagram of layout procedure along one wall of vehicle to determine if a fill-in stack is needed in the modified bonded block (MBB) load. Always begin the layout of an MBB pattern at the front of the vehicle with the first package lengthwise, the next two crosswise, next two lengthwise, and so forth. If a fill-in stack is needed, it can be placed between any two blocks, but should not be placed at the very rear of the load as it would not be stable.

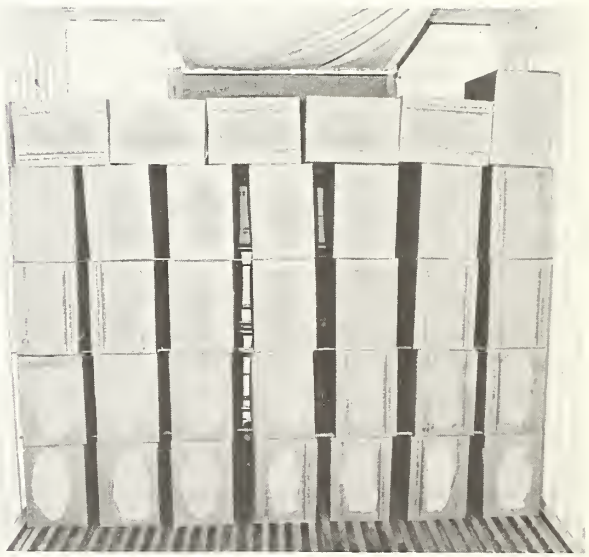

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FIGURE 5.—Header stack suitable for use in the modified bonded block (MBB) load in figures 2 and 3 or the pigeonhole (PH) load in figures 5 and 6. Air spaces in the header stack must aline with those in the MBB or PH load. Note the wooden car stripping placed between layers for stability. This stack can also be used as a fill-in stack for spacing purposes between any two blocks in the MBB load.

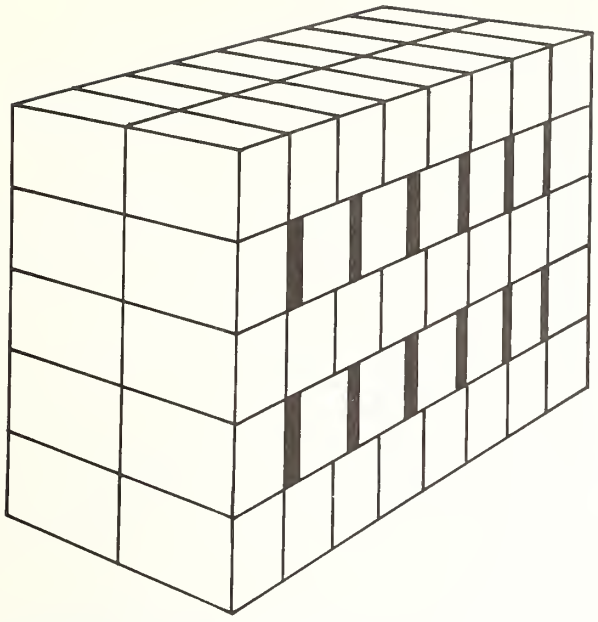

FIGURE 6.—Diagram of a pigeonhole (PH) load pattern. Air circulates horizontally from rear to front of load in alternate layers.

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FIGURE 7.—Cross section of one of the pigeonhole (PH) loads used in test shipments to Europe. Top layer cartons would normally be on bottoms also, but because of insufficient boxes, the smaller number of cartons were placed on sides in the top layer.

crease load stability as compared with the other PH pattern. In a PH load, the bottom layer should always be solid to properly support the overhead weight of the load.

A header stack (fig. 5) is essential with a PH load pattern, unless the vehicle has the built-in spacers on the front bulkhead to allow the returning air to pass down to the air return. These spacers consist of several vertical strips capped off at the top with a horizontal strip. If a header stack is used, the top layer must be solid to seal off the channels in the stack and prevent cold air from passing directly down from above the load and satisfying the thermostat before the load is properly cooled. To provide stability, header or fill-in stacks should either have car stripping (narrow, thin strips of wood) or fiber adhesive tape between layers reaching from one side of the vehicle to the other.

RESULTS

Temperatures in Van Containers

The MBB and PH load patterns were equally satisfactory in maintaining uniform and acceptable temperatures throughout the load. In tests 2, 3, and 4, the minimum and maximum temperatures within the loads differed by only 2° or 3° F. Uniformity was poorest in test 1 where temperature differences averaged 5° in each load pattern. Load temperatures averaged 37° or 38° in seven of the vans and 36° in one (figs. 8 through 11 and table 2).

In test 1, lettuce in one van did not start to cool down as soon as that in the other after transfer of the cartons at New Orleans because of a temporary 1-day equipment malfunction in the van containing the PH pattern (fig. 8). For unknown reasons, the temperature of the discharge air in both vans in test 1 temporarily increased sharply during the latter part of the trip, causing a slight increase in lettuce temperature.

In test 2, the rise in air temperature in both vans at the beginning and end of the ocean trip (fig. 9) is attributed to lack of electricity for the refrigeration units between the time the units were disconnected and reconnected on dock or ship. However, lettuce temperatures were not significantly affected.

Temperatures appear to be more erratic in the lettuce shipped to Hong Kong (figs. 10 and 11)

than in that shipped to Europe (figs. 8 and 9) because of differences in instrumenting these tests. The recording thermometers used in tests 1 and 2 have a lag time due to their bulk, and therefore may not reflect the extremes in temperatures, which actually occurred for short periods of time. The thermocouples used in tests 3 and 4 have no lag and thus reflect the temperature at the time of measurement (twice daily).

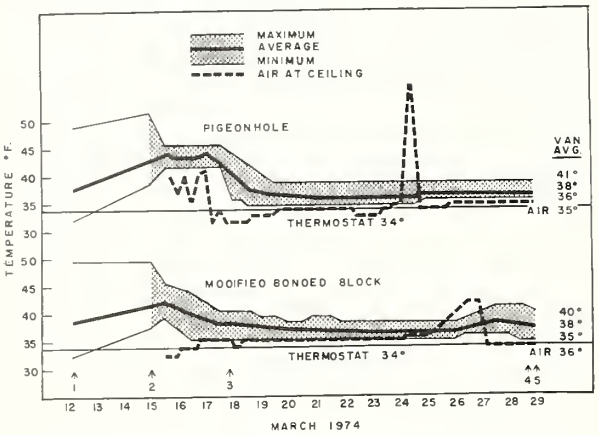

FIGURE 8.—Transit temperatures of lettuce loaded in two spaced patterns and shipped in refrigerated van containers from New Orleans, La., to Delft, the Netherlands (test 1). (1) Trailer with lettuce for both vans loaded at Blythe, Calif. (2) Lettuce transferred from trailer to van containers at New Orleans, La. (3) Ship left New Orleans, La. (4) Ship arrived at Rotterdam, the Netherlands. (5) Lettuce unloaded at Delft, the Netherlands.

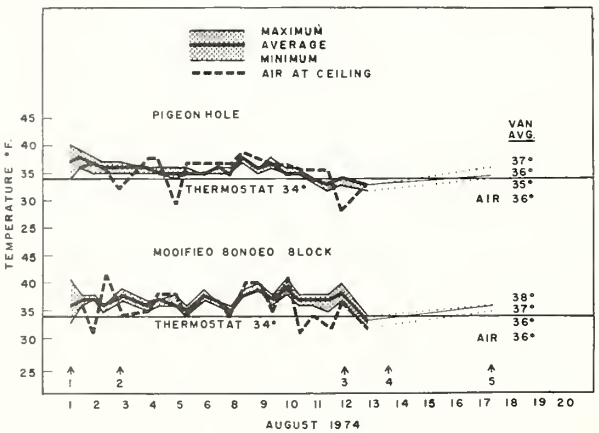

FIGURE 9.—Transit temperatures of lettuce shipped in two spaced load patterns from Jersey City, N.J., to Delft, the Netherlands. (1) Trailer with lettuce for both vans loaded at Salinas, Calif. (test 2). (2) Lettuce transferred from trailer to van containers at Jersey City, N.J. (3) Ship left Elizabeth, N.J. (4) Ship arrived at Rotterdam, the Netherlands. (5) Lettuce unloaded at Delft, the Netherlands.

Temperatures in Truck Trailers

Lettuce temperatures in tests 1 and 2 averaged 38° and 39° F, respectively, at time of loading into the trailers at shipping point (table 2). Lettuce temperature should be as close to 32° as feasible at loading. Temperature variation in the loads also was great at this time, ranging from 32° to 49° in test 1 and 35° to 42° in test 2. The highest temper-

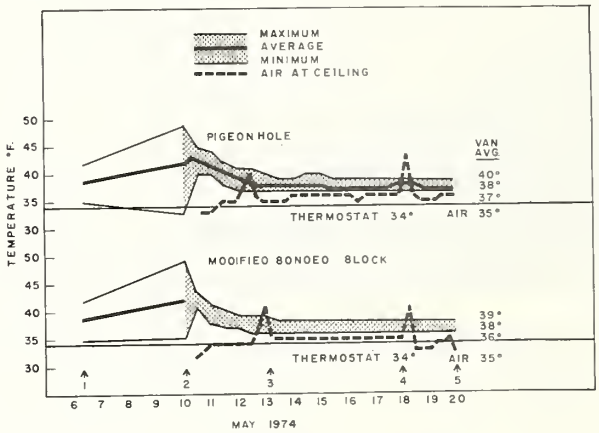

FIGURE 10.—Transit temperatures of lettuce shipped in two spaced load patterns from Salinas, Calif., to Hong Kong. No temperatures measured after leaving Yokohama until time of unloading at Hong Kong. (1) Van containers loaded at Salinas, Calif. (test 3). (2) Ship left Oakland, Calif. (3) Stop for cargo exchange at Yokohama, Japan. (4) Stop for cargo exchange at Kobe, Japan. (5) Ship arrived at Hong Kong.

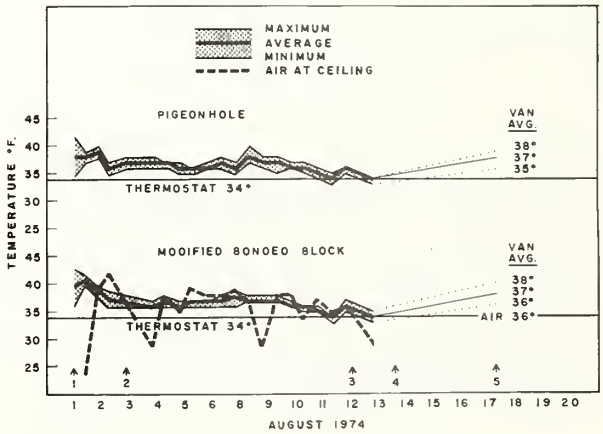

FIGURE 11.—Transit temperatures of lettuce shipped in two spaced load patterns from Salinas, Calif., to Hong Kong. No temperatures measured after leaving Yokohama until time of unloading at Hong Kong (test 4). (1) Van containers loaded at Salinas, Calif. (2) Ship left Oakland, Calif. (3) Stop for cargo exchange at Yokohama, Japan. (4) Stop for cargo exchange at Kobe, Japan. (5) Ship arrived at Hong Kong.

TABLE 2.—*Transit temperatures in refrigerated van containers of lettuce during export tests comparing two spaced load patterns* [1]

Test No.	Load pattern [2]	Lettuce temperatures: At shipping point [3] Range	At shipping point [3] Ave.	At transfer point [4] Range	At transfer point [4] Ave.	Average in vans during transit [5] Min.	Average in vans during transit [5] Max.	Average in vans during transit [5] Ave.	Average air temperatures [6]
		°F	°F	°F	°F	°F	°F	°F	°F
1	MBB	32–49	38	37–49	42	35	40	38	36
	PH			39–51	44	36	41	38	35
2	MBB	35–42	39	35–49	42	36	39	38	35
	PH			33–49	42	37	40	38	35
3	MBB	33–41	36	-----	--	36	38	37	36
	PH	34–40	37	-----	--	35	37	36	36
4	MBB	36–43	39	-----	--	36	38	37	36
	PH	34–42	38	-----	--	35	38	37	--

[1] Lettuce in tests 1 and 2 was trucked over land in refrigerated trailers from shipping point to point of transfer into refrigerated van containers. Lettuce in tests 3 and 4 was loaded directly into refrigerated van containers at shipping point. Solid, nonspaced loads were used in the trailers. The spaced loads were used in the van containers. The thermostats were set at 34° to 36° F in the trailers and at 34° in the vans.

[2] MBB, modified bonded block pattern; PH, pigeonhole pattern. See text for description of loads.

[3] Blythe, Calif., test 1; Salinas, Calif., tests 2, 3, and 4.

[4] New Orleans, La., test 1; Jersey City, N.J., test 2.

[5] Averages from time of loading into the vans until time of unloading at destination (Delft, the Netherlands, for tests 1 and 2; Hong Kong for tests 3 and 4).

[6] At air duct opening above load.

atures were measured in hard heads, which do not vacuum cool as rapidly as firm heads. Lettuce temperatures in these trailers increased during transit to an average of 43° and 42°, respectively, although the thermostats were set at 34° to 36°. The wide variation in temperatures (14° spread in test 1 and 16° in test 2) at time of transfer of the cartons from the truck trailer into the vans indicates that the solid loading pattern used in the truck trailers from California to the ports did not allow adequate air circulation throughout the load. In another test, lettuce temperatures in the trailer ranged from 31° to 48°, averaging 41° at time of unloading at the port. This export test was canceled because the trailer arrived at the port too late for shipment.

Load Stability

There was no appreciable shifting of the load in any of the test vans. Although the cartons used in all tests were nonwaxed, crushing of the bottom layers did not occur to an appreciable extent in any load. In some vans, the bottom layer of the stack nearest the rear door had been compressed about 2 inches by the overhead weight of the load, but the cartons in the bottom layer of the rest of the load were not crushed. This compression was not influenced by loading pattern.

Load Size

Load sizes differed somewhat in every van tested, depending on the size of package and the load pattern used. About 550 to 600 cartons of lettuce were placed in each van. Neither the MBB nor PH load pattern will consistently accommodate more packages of produce in a vehicle (van or trailer) than the other due to differences in package and vehicle dimensions. In some situations, the MBB pattern will accommodate a greater number of packages than the PH pattern, and in other situations, the reverse will be true. As a general guideline, either spaced loading pattern will reduce the number of packages that can be utilized in a given vehicle (van or trailer) by about 7 percent, compared with a solid loading pattern. Because the export freight rate for lettuce is generally on a per package rather than a per van basis, the slight reduction in package count does not increase freight costs. Even if the slight reduction in package count did

increase freight costs, a solid load should not be used in overseas shipments of lettuce because of the danger of reduced lettuce quality from inadequate air circulation and warm temperatures.

Lettuce Quality

There was no commercially significant difference in the quality of the lettuce that could be attributed to the load pattern (table 3). An average of about 5 percent of the heads required some "retail" trimming at time of arrival; this trimming made all of the heads salable. At the second examination, after the lettuce had been held for several days at 50° F, an average of about 12 percent of the heads required retail trimming; 1 percent of these heads could not be made salable primarily because of excessive decay. Total trimming losses (including retail and consumer trimming) averaged about 9 percent at the first examination and about 12 percent at the second examination.

Although some crushing and bruising of lettuce in the test cartons may have occurred in transit, much of it must have occurred during the harvesting and packing operations, because the test packages were not damaged or crushed during transit.

The increased percentage of heads rated moderate or severe for crushing and bruising after holding the lettuce at 50° F is attributed to increased discoloration of the damaged tissue during this time and, thus, greater prominence of the injury.

TABLE 3.—*Quality of lettuce on arrival in Europe or the Far East as influenced by spaced loading patterns in refrigerated van containers* [1]

Examination and load pattern [2]	Heads rated "good" or better [3]	Salable heads		Trimming losses [5]			Serious [6] crushing and bruising
		Without retail trimming [4]	After retail trimming	Retail trim	Consumer trim	Total	
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
First examination [7]							
MBB	60	93	100	2	7	9	4
PH	66	97	100	1	7	8	1
Second examination [8]							
MBB	41	85	99	4	7	12	10
PH	38	91	99	4	8	12	12

[1] Average of 4 paired test shipments, 2 to Europe and 2 to Hong Kong. 6 test boxes of lettuce were evaluated per van shipped to Europe and 3 per van shipped to Hong Kong. All heads were film wrapped at origin.

[2] MBB, modified bonded block pattern; PH, pigeonhole pattern.

[3] Before retail trimming.

[4] Heads rated "fair" or better.

[5] Trimming losses calculated on a weight basis; consumer trim based on removal of all remaining defective tissue.

[6] Rated moderate or severe (injury deep within the head).

[7] As soon after arrival as possible, usually after the lettuce had been held overnight at 34° F. Half the heads in each carton were evaluated at each examination.

[8] After a subsequent holding period at 50° F—4 or 5 days in Europe, 3 days in Hong Kong.

DISCUSSION

Because the two spaced loading patterns tested for lettuce were equally satisfactory in providing uniform temperatures throughout the load, the choice of pattern should be based on economic or other factors. The MBB pattern takes somewhat longer to load and is somewhat more difficult to stack than the PH pattern. Consequently, loading crews generally do not like to stack the MBB load, and may even charge a premium for loading this pattern. The principal advantage of the MBB over the PH pattern is that it is more foolproof because of the many interconnecting vertical and horizontal airspaces throughout the load. Thus, an occasional error in loading, such as not leaving enough space between some cartons, will not interfere appreciably with air circulation. In contrast, if the loading crew should forget to leave any air spaces in only one stack of the PH load, all length-

wise air channels would be blocked, or if no space was left between two cartons in one of the spaced layers of the PH load, that particular air channel would be blocked throughout the length of the van.

Package and vehicle dimensions also will influence the choice of loading pattern. In some cases, the MBB pattern will provide the best-sized air channels, and, in other cases, the PH pattern will be best.

The following generalizations apply to both the MBB and PH spaced loading patterns:

- Air channels should be 1½ to 3 inches wide.
- Because of the different carton and vehicle sizes, a fill-in row of cartons along one wall may be needed to permit proper spacing of the bulk of the load.
- Cartons in this fill-in row may be placed on side or on bottom, either lengthwise or crosswise in the vehicle, whichever provides the best spacing for the pattern load.
- Cartons should never be stacked so high that they block the air ducts.

Although the nonwaxed cartons used in these eight van loads were not crushed during transit, it should be pointed out that they were unloaded into warehouses that were not more than 10 miles from the port. Transport over the road for greater distances at destination could cause excessive crushing of the bottom layer packages, because the cartons were weakened somewhat by the moisture they absorbed during the ocean trip. Therefore, shippers should seriously consider using the stronger waxed carton for exporting lettuce that will have to be transported greater distances from the port.

The lettuce temperatures at time of loading into the trailers in the harvest area indicate that improvement is needed in precooling.

Solid load patterns should never be used in vans of lettuce for export, as evidenced by the excessively high temperatures in the lettuce after just a few days of trailer transport using a solid pattern.

APPENDIX

Here are some general guidelines for consideration by shippers who plan to export lettuce:

1. Ship only top-quality lettuce. Because decay is the primary deterioration problem, a zero decay tolerance should be used at shipping point. A zero tolerance should also be used for internal rib necrosis and rusty brown discoloration. Do not export hard, overmature heads.
2. Have the lettuce inspected again if it is transferred to another vehicle before export, for example, at time of transfer on the East or gulf coast from the over-the-road trailer to a van container. If decay is found, or if quality is not excellent, do not export the lettuce.
3. Insist that the lettuce be precooled to 32° to 35° F.
4. Keep delays between harvesting and loading into the transportation vehicle to a minimum.
5. Export wrapped, rather than "naked," lettuce to eliminate the older leaves, which are more susceptible to decay, and to reduce the spread of decay from one head to another.
6. Start the refrigeration unit of the transport vehicle before loading to make sure it operates properly.
7. Use a spaced load pattern, either PH or MBB, in over-the-road trailers that must travel more than 1 day to the port where the lettuce will be transferred to the vans.
8. Use a spaced load pattern in the ocean van container. A header stack must be used with the PH pattern unless the van or trailer contains the proper spacer strips at the front to permit air movement from the load to the air return.
9. Request a van container with continuous air circulation. In many older units, the fan operates only while the compressor is on.
10. Maintain transit temperatures as close to 32° F as possible, with safeguards against freezing.

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AGRICULTURAL RESEARCH SERVICE
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